EXHIBIT 3

Ocular Foam Marking Round Injury: a case report and a literature review

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Abstract

Purpose

To report a case of a 25-year-old male who sustained significant ocular trauma from a confirmed foam marking round and to review the literature on ocular injuries caused by less-lethal munitions.

Observations

A 25-year-old male presented to the emergency department with acute pain and vision loss in his left eye after being struck by a foam marking round. Initial exam showed significant periorbital ecchymosis, multiple eyelid lacerations, microhyphema, and vitreous hemorrhage. Computed tomography (CT) revealed fractures of the inferior and medial orbital walls. Optical coherence tomography (OCT) demonstrated full-thickness macular hole. Microhyphema resolved after 15 days with steroid and mydriatic drops. Vision at 60 days after injury stabilized at 20/60. Repeat OCT at this time revealed closure of the macular hole. Care for the patient is ongoing.

Conclusions and Importance

Foam rounds can cause a pattern of vision-threatening ocular trauma similar to that caused by rubber bullets with the add risk of lacerative and chemical injury. Isolated reports of significant foam round-related injuries during recent protests have been reported in the lay press, but epidemiologic and clinical information on the subject is absent. The interchangeable use of "foam rounds" and "rubber bullets" in the literature may contribute to this lack of information. Current legislative efforts at multiple levels of government aptly recognize the potential for blinding injury by all forms of less-lethal munitions based upon the body of scientific evidence on rubber bullets. However, growing specificity in the language around less-lethal munitions in the public sphere should be reflected in the scientific literature.

Keywords

Marking round, Foam Round, Rubber bullet, Ocular trauma, Less-lethal munitions

Introduction

Greater awareness of the significant ocular injuries and potential mortality associated with rubber bullets have mobilized efforts to ban these munitions from being used against civilian populations in the United States. However, the epidemiology and pattern of injury regarding ocular foam rounds injury remains poorly understood.

Case Report

A 25-year-old male with no previous medical history presented to the emergency department (ED) with acute vision loss and pain in the left eye after being struck by projectile during a protest. Initially, he believed that he had been struck by a rubber bullet, but the projectile obtained by the patient was subsequently identified as a foam marking round (Fig 1a). A green powdery substance was dispersed around the site of injury. At the time of presentation to the Emergency Department (ED), he demonstrated intact airway, breathing, and circulation and denied history of recent alcohol or drug use. Vital signs at triage were within normal limits except for a reduced heart rate of 47.

On initial exam, the patient reported 10/10, stabbing pain in the left eye that worsened with downgaze. He also reported reduced vision in the left eye with photophobia, floaters, and photopsia. Examination of the right eye was within normal limits. The left eye demonstrated reduced vision at 20/50 with the near card. Intraocular pressure (IOP) was measured to be 14 mmHg by Tono-Pen. Pupil was round and reactive to light. Patient reported direct photophobia but denied consensual photophobia. Extraocular motility exam was significant for -2 inferior gaze restriction on the left side. pH testing was not performed.

Examination of the left adnexa revealed diffuse periorbital ecchymosis and edema. Two lacerations were noted: one 3-cm laceration on the upper eyelid and a 2-cm laceration located just inferior to the lower eyelid. Neither involved the eyelid margins or the canalicular system (Fig 1b). Green pigment was found dispersed over the ocular surface and eyelids. The conjunctiva revealed diffuse 1+ injection with a localized subconjunctival hemorrhage temporally. The cornea was clear and without signs of ulceration or chemical injury. Examination of the anterior chamber demonstrated 4+ nonlayered RBC and an iris hemorrhage at 3 o'clock. Detailed dilated fundus exam at this time was limited by significant microhyphema in the anterior chamber and patient discomfort.

Orbital CT revealed an intact globe and fractures involving both the inferior and medial walls of the left orbit as well as a layering hemorrhage in the left maxillary sinus (Fig 2).

The eye was irrigated with normal saline and both eyelid lacerations were repaired. Treatment for the microhyphema was initiated with PredForte QID and tropicamide BID. The orbital fractures were managed conservatively, without surgical intervention.

The day after the injury, the patient's vision had worsened to 20/300 in the left eye and improved with pinhole to 20/200. IOP remained within normal range at 17 mmHg. Pupils were reactive, but now demonstrated posterior synechiae. Dilated fundus exam revealed inferior vitreous hemorrhage without signs of retinal tear or detachment. OCT demonstrated full-thickness macular hole with cystoid macular edema (Fig 3a). Frequency of PredForte was increased to once every hour and consultation with the Retina Service was scheduled for management of the vitreous hemorrhage and macular hole.

The patient was examined again at three days post injury. He reported improved pain, edema, and diplopia. Vision in the left eye was 20/200 with improvement to 20/100 with pinhole. No posterior synechiae were appreciated. Patient continued to have -1 inferior gaze restriction.

On the fifth day post injury, his vision improved to 20/50 and IOP remained stable at 14mmHg. Forced ductions demonstrated full range of motion and axial positions of the eyes, measured with an Hertel exophthalmometer, were 17 and 18 millimeters, respectively. Persistent binocular diplopia due to orbital inflammation was treated with oral steroids. With improvement in the microhyphema, PredForte was decreased to QID.

Patient continued with progressive improvement in vision, diplopia, and pain at his subsequent four visits. IOP also remained stable throughout. At his last visit (60 days after injury), his vision had stabilized to 20/60 (ph 20/50). IOP was 14. Vitreous hemorrhage showed signs of gradual resolution. Repeat OCT revealed closure of the full-thickness macular hole with nasal IS/OS drop out (Fig 3b).

Care for the patient is ongoing. See Fig 4 for timeline of management.

Discussion

Rubber and Plastic Bullets and Bean Bag Rounds

Rubber bullets were first used by British police in 1970 in Northern Ireland and are now used worldwide. They were designed to be shot at the ground and ricochet to strike the lower extremities from a distance of approximately 40 meters. However, the inherent lack of precision of these rounds combined with their use outside of recommended parameters often result in significant morbidity and even mortality (1). Studies of different forms of rubber bullets across contexts consistently demonstrate significant ocular trauma from these rounds (2). Ocular rubber bullet injuries often result resulting in multiple fractures of the orbit and blunt trauma to both the anterior and posterior segments of the eye (Table 1).

Plastic bullets, introduced in 1975, were designed for improved accuracy. Ballistic analysis in 1996, however, demonstrated an almost random distribution of trajectories across a surface area

of 2 meters when plastic bullets were fired at a distance of 20 meters. From this distance, the probability of striking the head/neck region and the eyes was estimated to be 34.7% and 2.3%, respectively (3). Compared to rubber bullets, plastic bullets were associated with less serious injuries to the face and chest, but more severe injuries to the skull and brain, which were also more likely to be fatal (4).

Most forms of bean bag rounds consist of a fabric bag filled with lead shot pellets, which are fired from a 12-gauge shot gun. A 1974 study by the US army concluded that test shot data "indicate a considerably higher probably of undesirable effects than of desirable effects" (5), but bean bags were introduced in the US in 1994. According to a voluntary survey of US law enforcement agencies in 2004, bean bag rounds accounted for 65% of all less-lethal projectiles in the country (6).

Foam/Sponge/Marking Rounds
While rubber bullets were designed for nonspecific crowd dispersal, foam or sponge rounds were designed for precision as a "point-of-aim, point-of-impact, direct-fire round". The increased velocity of these rounds improves accuracy and exponentially increases the kinetic energy transmitted upon impact (Table 1). The elastic "sponge" tip is designed to attenuate some of this energy and can be loaded with an irritant or marking payload, as was seen in this case.

In a case series of 11 patients by Suyama et al, foam rounds were more likely to cause lacerative injuries than rubber bullets and were just as likely to cause blunt trauma (7). The lacerations may be due to the coarse texture of the foam tip combined with the velocity and spin of projectile exerting traction on the skin. Though four of these cases involved injuries to the head, no ocular involvement was reported.

Foam rounds have also been implicated two cases where they caused severe internal organ injury with minimal effect on incapacitation. In one lethal case, an inmate sustained a shot to the head from approximately 53 feet. Though he suffered a 5 cm laceration on his forehead, he remained combative until he lost consciousness an hour later. He died 47 days later due to intracranial trauma (8). In a separate autopsy study, foam rounds fired from 25 feet failed to incapacitate an aggressive individual, but still caused unexpectedly severe pulmonary contusion. The amount of force generated by round was deemed to sufficient force to rupture the contents of the eye (9).

Although there are no reports of ocular foam round injuries in the literature, the clinical features of this case support previous studies that have documented significant lacerative and blunt injuries from these munitions. Additionally, the pattern of injury presented bears resemblance to that caused by rubber bullets (Table 1). Multiple studies on ocular rubber bullets injury describe strong associations with orbital fracture, lid lacerations, hyphema, retinal trauma, and globe rupture (10,11).

There are no descriptions of chemical injury secondary to foam rounds in the literature. The absence of corneal pathology in this case supports documentation that describe the green marking pigment as chemically inert. However, technical specifications also disclose possible exposures to lead salts, methylene chloride, and hexavalent chromium, all of which have been linked to deleterious effects on the eye. Foam rounds can also be loaded with oleoresin capsicum (OC, pepper spray), chloroacetophenone (CN, Mace), and orthochlorobenzalmalononitrile (CS, tear gas) (12). Therefore, it may be prudent for clinicians to pursue pH testing and generous flushing when foam round injury is suspected.

Conclusion

This is the first case report to describe the pattern of ocular injury caused by a confirmed foam marking round. The multiple, concomitant injuries to ocular structures resemble descriptions of injuries caused by rubber bullets in the literature. Although the marking pigment appears to be inert, chemical injury to the eye should be considered due to the potential involvement of irritants.

In recent civil protests across the US, there have been isolated reports in the press about significant injuries caused by foam rounds, including the blinding of photojournalist in Minneapolis. Multiple factors contribute to the difficulty of estimating the prevalence of foam round-associated injuries. Police are not required to maintain records of less lethal munitions and, as this case demonstrates, traumatic and chemical injuries due to other less-lethal munitions may be mis-attributed to rubber bullets or tear gas. Injured victims are seldom able to recover the specific projectile used against them.

The lack of awareness around less-lethal munitions in the public is paralleled by the use of outdated terminology in the scientific literature. All three studies on foam rounds that were retrieved for this review used the terms “rubber bullets” and “foam rounds” interchangeably. While this practice may have been acceptable for the time, there is evidence that public language around these munitions is becoming more specific. Responding to questions regarding the blinding of the photojournalist, the spokesperson for the Minneapolis Police Department responded, “We use 40mm less-lethal foam marking rounds. We do not use rubber bullets” (13). This ambiguity also makes it difficult to confidently interpret the findings of more recent studies on “40mm rubber bullets” that do not further specify the type of round used (11).

In June 2020, the American Academy of Ophthalmology (AAO) called for domestic law enforcement to end the use of rubber bullets against protesters (14). State and federal legislation prohibiting the use of chemical and all kinetic impact projectiles, namely S.8516 proposed by New York State Senator Ramos and the No Tear Gas or Projectiles Act proposed by Senators Markey and Sanders, closely followed (15) (16).

Legislative efforts to protect the vision and health of individuals exercising their freedom of speech have been supported by the body of scientific evidence on rubber bullets. Public language that differentiates rubber bullets and foam rounds should be reflected in the scientific literature, especially as use of foam rounds in crowd control may be increasing. The terms “foam”, “sponge”, and “marking” are misleading. While these munitions are lighter than rubber bullets and feature collapsing tips, the velocity at which these rounds are fired result in unexpectedly severe trauma.

Patient Consent

The patient consented to the publication of the case in writing.

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CRediT Author Statement:

Hyun Jun Kim: Writing - Original Draft, Project administration, **Sameerah Alkhairy**: Data curation, **Lisa D Kelly**: Conceptualization, Writing - Reviewing, and editing, and Supervision

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Citation corrections that will be added after edits to the manuscript have been finalized:

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Figures Captions

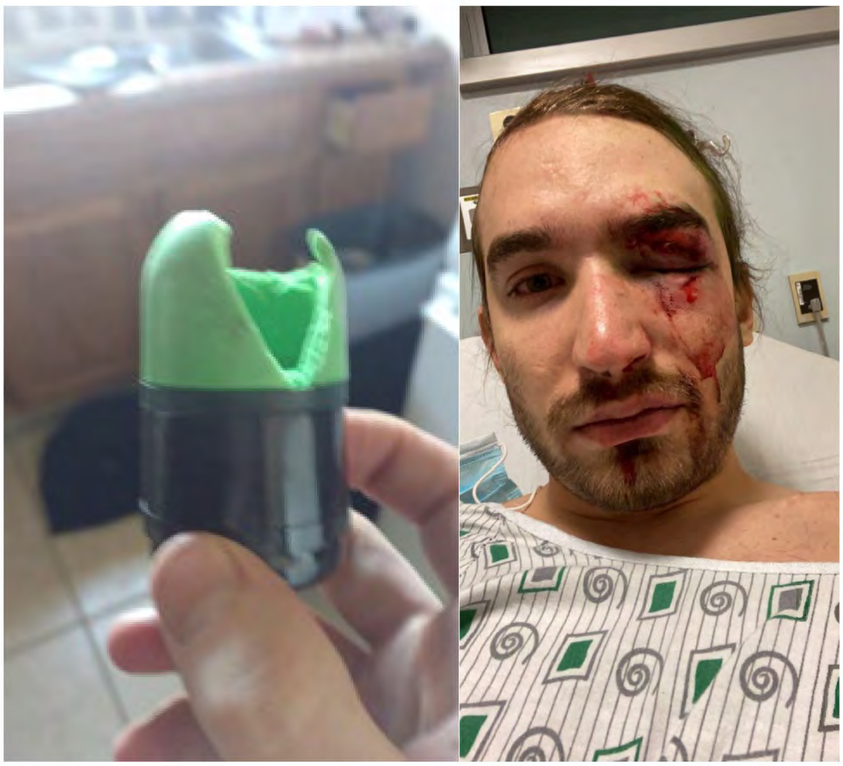

Fig 1. Photographs after injury **a.** Foam marking round as recovered by the patient in Cincinnati, Ohio, USA. **b.** external photograph demonstrating significant periorbital ecchymosis and edema and eyelid lacerations to the left upper eyelid and just inferior to the lower eyelid.

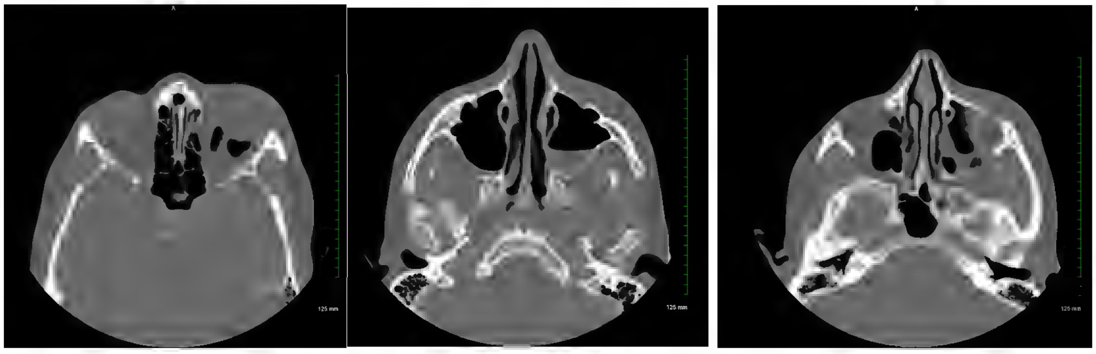

Fig 2. Non-contrast CT of the orbits. **a** Sagittal bone window shows fracture medial wall of the left orbit with intraconal gas. **b** Sagittal bone window shows layering hemorrhage in the left maxillary sinus **c** changes to the inferior rectus as it passes over the fractured fragment of the orbital floor.

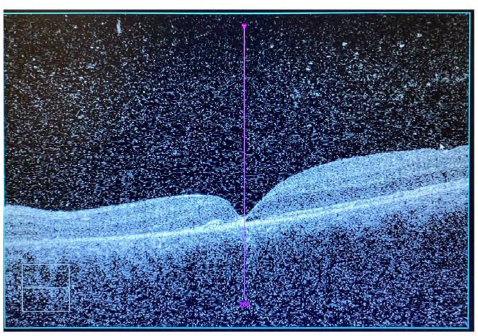

Fig 3. OCT of the macula. **a** OCT demonstrating full-thickness macular hole at injury. **b** Follow-up OCT 60 days after injury demonstrates closure of the macular hole and IS/OS drop-out nasally.

Fig 4. Timeline depicting progression of management.